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# Critical velocity shear for triggering L-H transition in the HL-2A tokamak

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In magnetic fusion devices, the transition from the low (L-) to high confinement mode (H-mode) is triggered when the heating power exceeds the transition power threshold. The physical mechanism of L-H transition is widely explained by the turbulence suppression by E × B velocity shear [1,2]. This work presents the dynamics of shear flows and turbulence in the pedestal region during the L-H transition in the HL-2A tokamak. It has been shown that the velocity shear increases significantly across the L–H transition, suppressing turbulent transport and leading to the formation of the pedestal transport barrier. Comparing the velocity shear to the diamagnetic term and the poloidal and toroidal terms of $E_r$, during the L-H transition, the toroidal and poloidal velocity terms are nearly unchanged, whereas the ion diamagnetic term has the similar tendency as the velocity shear $|\partial u_\perp/\partial r|$. The results show that the diamagnetic term plays a dominant role, while the contributions by the poloidal and toroidal terms are negligible, which is consistent with the previous results in HL-2A [3,4].

Statistical analysis showed that the velocity shear must increase to a critical value to permit the L-H transition, meaning that the critical value plays as a velocity shear threshold for the L-H transition. Once the velocity shear increases and reaches the critical value, the L-H transition occurs. To further understand the role of the critical velocity shear in the transitions, the parametric dependence of the critical value on plasma parameters have been statistically studied. Figure 1 shows the critical velocity shear as a function of plasma density at L-I transition (blue) and I-H transition (red). The results further confirm the existences of L-I transition and I-H transitions velocity shear threshold. The transition happens when the velocity shear exceeds the threshold. Apparently, the critical velocity shear for I-H transition is higher than that of the L-I transition. Since the velocity shear is dominated by the ion diamagnetic term ($\nabla P_i/eZ_i n_i$), while the ion pressure gradient in H-mode is much steeper than L-mode and I-phase. It has also been found that the critical velocity shear is independent on the plasma density and heating power. Gyro-kinetic simulations showed that the normalized turbulence linear growth rate is not sensitive to the normalized density gradient and normalized temperature gradient that investigated in the statistics, suggesting that the normalized turbulence linear growth rate could not be strongly affected by plasma density and heating power. The results are consistent with the experimental observations in figure 1 [5]. A substantially constant velocity shear can suppress the turbulence transport and leading to the L-H transition, since the turbulence linear growth rate is nearly constant.

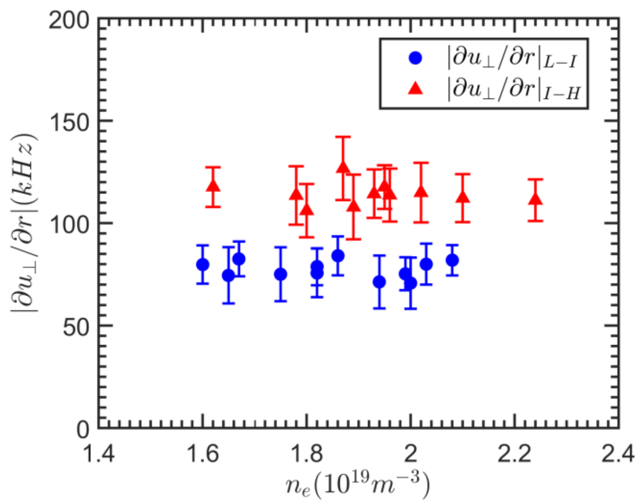


Figure 1. Statistical critical velocity shear at L-I (blue) and I-H (red) transition as a function of density

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